



Review

Medico-legal implications of traumatic cataract

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ABSTRACT

Traumatic cataract is due to lens damage when mechanical, irradiative, electrical or chemical agents injury the globe. The appearance of a traumatic cataract is typically short and unilateral with rare spontaneous resolution and often involves other ocular anatomical areas. Medico-legal evaluation of the appearance and the consequences of a traumatic cataract requires a correct methodological approach with the support of qualified ophthalmological competences.

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1. Introduction

Serious ocular trauma may damage the crystalline lens in 25–30% of involved subjects.^{1,2}

Traumatic cataract occurs after 39% of open globe injuries and 11% of closed globe injuries and is due to the application of mechanical, irradiative, electrical or chemical insults.^{1–5}

Lens opacities are generally localized, stationary and without significant loss of vision, about 15% are wide or complete and permanent, with disability due to significant visual dysfunction and require the surgical extraction within 18 months of the injury.²

Lens injuries may often associate lesions involving other ocular structures and may cause serious and complex functional consequences.^{1,2}

The dynamic of the traumatic event, the assessment of the injuring agent, the dating and timing of the lens lesions, the level and prognosis of visual dysfunction, the exaggeration or minimization of symptoms and sometimes the presence of medical malpractice involving post-traumatic care are usual questions when a medico-legal evaluation of a traumatic cataract is required.^{6–9}

A correct medico-legal approach in cases of traumatic cataract should be applied with a prudent analysis of all available data on the injuring agent, on the dynamic profile of the trauma and its

clinical consequences and with the support of a qualified ophthalmologist consultant able to plan all the necessary and suppletive clinical investigations.^{6–9}

2. Causes of traumatic cataract

2.1. Mechanical lens insults

The main causes of traumatic cataract produced by mechanical insults are due to different epidemiological events:

- Home accidents or working accidents due to pointed or sharp instruments (needles, pens, knives, point of scissors, lead shot), specific technical instruments or foreign bodies (metal, wood, glass or mineral splinters).^{10–13}
- Road traffic accidents caused by motorcycles or motor vehicle crashes. Sometimes the air bag deployment may cause damage to the globe: gases expand air bags at 100–200 mph speed completing the entire inflation within 0.05 s.^{10–15}
- Severe head trauma to the skull, at the nasal or frontal area, or to the cervical skeleton (accelerative and decelerative movements of skull and spinal axis during whiplash may involve the globe causing vitreous or lens lesions).^{10–16}
- Recreational activities using rubber balls, party balloons, corks, elastic corks, bungee cords, airguns, paintball guns.^{17–22}
- Sport activities such as baseball, softball, fishing, basketball, racquetball, golf, tennis, soccer, football, boxing.^{23–26}
- Assault injuries using fist blows or different instruments or objects.^{10–12,27,28}

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- Firearms or explosive injuries due to arson, bombs, fire-crackers, fireworks, bullets, metal fragments and debris propelled by explosions, grains of gunpowder ignited and propelled at greater velocity, high temperature gases.^{10–13,27,28}
- Torture causing blows to the head and eyes by heavy weapons, beating or whipping, kicking, electrical burns, cigarette burns, stab wounds, razor cuts.^{10–13,27,28}

The seriousness of a traumatic cataract depends on a wide variety of factors such as type of injuring agent, impact point, level of energy delivered (kinetic, thermal, chemical reduction or oxidation, or other), absence of ocular protective devices, presence of pre-existing ocular diseases (lens degenerative processes, previous surgery) or systemic diseases (diabetes, connective diseases, autoimmune diseases).^{3,5,6,9}

Mechanical insults cause injuries due to different lesion producing patterns:

- Penetrating traumas generally produce isolated serious lesions in the lens with moderate contiguous lesions due to the diffusion of low amounts of energy to the proximate anatomical areas.

Penetrating traumas produce the disruption of the anterior capsule and the resulting injury has radially disposed striae appearance.

On the contrary blunt and concussive traumas produce serious lesions both in the lens and proximate anatomical districts due to the distribution of significant amounts of energy transmitted by oscillatory variations of the equatorial globe diameter which generate compressive and expansive shock waves.^{1–6,29}

The main protective factor of the eye-ball is the extension of the external margin of the orbital cavity.

However, when the size of the injuring object is smaller than the orbital diameter there is higher probability of involving the ocular tissue and causing significant damage.

The size of the opening area in the lens determines the morphology and the thickness of the cataract: when the opening area is large, the whole lens early becomes cloudy but in the case of a small opening area, the opacity will be localized at the site of penetration, sealing itself and being localized behind the site of penetration.^{1–6}

When a retention of metal fragments occurs a consequent siderosis of lens tissues is possible.^{1–6}

- Blunt traumas generally do not produce the violation of the anterior capsule and so the resulting injury has a rosette-shaped (due to opacified lens fibers), punctate or cobweb appearance but sometimes the posterior subcapsular districts may be involved.^{1–6}
- Concussive traumas generate coup and contrecoup forces due to the transmission of kinetic energy from the impact point to the lens, globe and contiguous tissue.

Concussive traumas generally do not produce the violation of the anterior capsule so the resulting injury has a rosette-shaped or punctate or cobweb appearance. Sometimes concussive traumas may involve the posterior subcapsular districts also.^{1–6}

When a significant amount of energy is applied, the Vossius Ring, which is a sign resulting from the imprinting of iris pigment on the anterior lens capsule, may appear.⁷

2.2. Irradiative insults

Irradiative insults are due to micro, infrared, thermal, ultraviolet and ionizing waves which damage the lens membrane and increase

its permeability, affecting the metabolism, the synthesis of proteins, the mitotic activity of lens cells and promoting the coagulation of lens proteins.

Physical radiation generally does not produce a complete violation of the anterior capsule but sometimes involves the posterior subcapsular districts and the resulting injury generally has a rosette-shaped appearance.

Irradiative lens trauma involves subjects under ultraviolet radiations, patients undergoing laser procedures or radiation treatment for malignant tumors, inadequately protected laser or X-ray technicians, atomic energy plants workers, metal or glass workers, fire or explosion accidents victims.^{1,3,5,11,30}

2.3. Electrical insults

Electrical insults are due to the application of high voltage which produces thermal energy delivery injuries at the lens tissues, structurally similar to those produced by irradiative insults.

Electrical cataract often becomes intumescent in a short time.

It generally occurs during industrial or home electrical accidents or during lightning.^{1,3,5,11,31–33}

2.4. Chemical insults

Chemical insults occur when acid or alkaline agents are applied to the lens.

Acid agents have a low diffusion velocity inside tissues, cause slow tissue protein coagulation and residual sclerosis.

Peripheral margins of opacities are limited and regular.

Chemical insults due to alkaline agents have a high diffusion velocity inside tissues and are more aggressive because they damage lipid bilayers of cell membranes so that tissues quickly become soften and intumescent.

Peripheral margins of opacities are wide and irregular.^{1,3,5,11,34}

3. Pathophysiology

The normal homeostasis of lens fibers, anatomically generated by the elongation of epithelial cells which constitute the cortex (youngest fibers) and the nucleus (oldest fibers) of the lens, is compromised every time a physical or chemical injuring agent is applied to the crystalline involving the capsule or the epithelial cells membranes, so that:

- The nutrition of the lens is no longer supported by the aqueous humor, the cation transport system is unable to regulate the intracellular water content and osmotic environment, the lens transparency is not maintained hence the intracellular enzymatic and metabolic activity is seriously compromised.
- An increase in intracellular water insoluble proteins and total protein content begins generating fibers with irregular dimensions and shape and with intracellular vacuolar spaces containing proteic material.

This proteic material is generated by oxidation, glycosylation, proteolysis, deamination, phosphorylation and carbamylation of normal soluble proteins leading to high-molecular-weight insoluble protein aggregates.

- Amorphous cavities, generated after epithelial cell degeneration, appear inside the lens thickness.
- A leakage of proteins from lens into surrounding tissues begins causing inflammatory processes.^{1–3,5,11,34,35}

The time velocity of cataract appearance is related to the integrity of the capsule, the number of epithelial cells involved and the degree of inflammatory response.

Capsule breakage, in cases of mechanical penetrating trauma, quickly promotes the entering of water inside the lens causing early intumescence.

On the other hand the age of the patient seems to influence the final appearance and evolution of the post traumatic cataract: younger individuals have a significant regeneration ability.^{1–3,5,11,34,35}

The absorption of a traumatic cataract may begin many weeks or months after the accident, inducing a prolonged decrease or disappearance of the opacities: this process is more frequent in younger individuals while absorbed cataracts rarely occurs in advanced age individuals.^{1–3,5,11,34,35}

When the development of a traumatic cataract begins the coagulation of lens fibers proteins turns the normal transparent crystalline structure into an opaque one compromising all the following lens functions:

- To maintain its own clarity.
- To converge rays of light onto the macula forming clear images of objects and providing refractive power to the optical system of the eye.
- To support the accommodation function.
- To absorb the ultraviolet light.^{1–3,5,11,34,35}

4. Complications

Lens displacement is the most frequent result of the application of a violent shock to the globe, generally causing the rupture of the zonules of Zinn fibers, while the position assumed by the crystalline differs in accordance with the direction of the injuring forces.

The lens may assume a vertical or lateral displacement.

The widening of the displacement differentiates:

- Subluxation: when the lens may remains in part lodged in the hyaloid fossa.
- Luxation: when the total or near total rupture of the suspensory apparatus causes the lens dislodging into the anterior chamber (between the iris and the cornea) or into the vitreous humor.

Sometimes the lens may engage into the pupillar orifice or into the subconjunctival cellular tissue (phacocoele).

Some rare times the lens may be even propelled from the eye (iris, vitreous humor may escape through corneal-scleral openings).

Typical clinical signs of lens displacement may be the loss of accommodation power, astigmatism, monocular diplopia, polyopia, paralytic dilatation of the pupil.

When the displaced lens becomes adherent and anchored to the iris or the cornea, due to organized membranes, an ulcerative keratitis or a glaucomatic iridocyclitis may occur.^{1,2,5,7,11,34,35,37}

Both in dislocated and nondislocated cases an undamaged lens remains clear for a long time, while degenerative changes of the epithelium, like disintegration and cleft formation in cortical layers, may occur after 3–4-months, followed by the formation of amorphous masses.

A ruptured capsule of a dislocated or nondislocated lens quickly becomes cataractous and permeable while lens proteins may escape and involve the aqueous humor and the trabecular system causing uveitis or secondary glaucoma.

When a cortex/vitreous/blood/fibrin mixture occurs a serious post-injury inflammation and a proliferative vitreoretinopathy may develop.

Iritis, iridocyclitis, local or general ophthalmitis frequently occurs in cases of open contaminated or extensively contused globe injuries involving the crystalline.¹

When a purulent panophthalmitis occurs a prompt surgical intervention and even enucleation or evisceration are required.

When the muscular structures of the iris are seriously damaged a post traumatic mydriasis may occur, inducing a permanent non-reactive pupillar condition to light stimuli.

The rupture of capillar vessels of the iris may cause the hemorrhagic involvement of the anterior chamber (ipoema-iridodialysis).

Both reversible and irreversible displacements, due to high mechanical energy application and to the transmission of shock waves through the vitreous humor, may involve retinal areas causing retinal injuries or detachment.^{1,2,5,7,11,34,35,37}

5. Medico-legal implications

Both open and closed globe injuries occurring after globe trauma may involve the lens.

The application of mechanical, irradiative, electrical or chemical insults induces lens fiber degeneration and coagulation, affecting the normal transparent crystalline structure which causes opacities interfering with vision.

Traumatic cataracts often become the cause of law suits for damages so that forensic doctors are called upon to state the cause, the nature, the timing and the consequences of such pathological events.^{1,2,5,7,9,11,34,35}

These questions frequently involve difficulties because the clinical background and experience of a forensic doctor concerning the field of ophthalmology, may be not adequate in examining a case of traumatic cataract.

The interaction of an expert ophthalmologist consultant with the medico-legal team called upon during claims or lawsuits is mandatory in improving the interpretation of all clinically collected data and to give a correct forensic diagnosis of traumatic cataract.

After the clinical diagnosis and the prognostic stand-point of a traumatic cataract has been asserted by an ophthalmologist, the medico-legal consultant has to answer the judicial questions, all of them requiring evidence supported opinions to solve the instances of the disputing parties and to provide the presiding judge objective elements for conclusive decisions.^{4,5,9,11,28,36,37}

Forensic doctors may be appointed as medical experts by a court or by investigatory authorities, insurance companies, private companies or by single individuals in order to provide the following testimonies:

- (1) The description of all the anatomical features of the lesions appearing immediately after the trauma and residual after all medical and surgical treatments, as the morphology of corneal lesions and its transparency variations, the morphology of pupil and iris lesions, the morphology of lens opacities and displacements.
- (2) An exhaustive and clear explanation of the dynamic profile of the accident as produced by mechanical, irradiative, electrical or chemical injuring agents.

It is necessary to evaluate the trajectory, the incidence angle at the impact point, the speed and the level of kinetic energy delivered by the injuring agent to the ocular structures damaged in cases of cataract due to the application of a mechanical insult.

- (3) The effective demonstration of the cause and effect relationship between the intervention of the traumatic agent and its effect on the genesis of all consequent anatomical lesions and visual dysfunctions.

- (4) The evaluation whether the final effect was caused by the intervention of one or more traumatic agents, differentiating singular and cumulative etiological effects and all time relationships between the intervention of a single traumatic agent or various traumatic agents and the arising of symptoms and lens opacities.
- (5) The assessment of the general eye function, after all applied medical or surgical treatments, involving the visual acuity and visual field, the refractive and accommodative processes, the globe tension variations, in order to estimate the incapacity to perform routine activities or to continue occupations and to estimate whether the actual condition may be stationary or will cause a permanent disability or will worsen with new pathological changes causing predictable or unpredictable consequences in the future.

Moreover, it could be necessary to investigate all medical and surgical therapies applied immediately after the trauma or at a later time in order to evaluate their prompt and valid profile or their cause and effect relationship with new injuries and future disabilities.

Sometimes a possible medical liability must be investigated in case of unskillful treatments not performed in conformity with clinical rules and practice.

- (6) The clarification whether the definitive eye function is the result of the trauma alone or whether the actual condition could be ascribed partly to the trauma and partly to pre-existing acquired or congenital diseases in the individual.

This is a typical problem solving process when a forensic approach is applied after a traumatic lesion.

The behavior of subjects who sometimes try to avoid obligations such as military service and social duties or to amplify the consequences of the trauma in order to claim more damage or to obtain more compensation or pensions, must be identified.

Slight lesions of vision may constitute a real obstacle in the performance of different professions or jobs, so that subjects may amplify the consequences of an accident, as simulating blindness, or may minimize or hide symptoms in hope of obtaining a larger settlement or higher job qualifications or assignments.

An expert forensic consultant supported by an ophthalmologist must detect malingering or feigning.

Moreover, care must be applied not to consider every subject a malinger just performing correct clinical investigations and visual tests with the support of an ophthalmologist.

On the contrary the medico-legal evaluation may be not difficult when inspecting disabled subjects, because the reported symptoms are generally not proportional to the degree and features of the objective dysfunctions.

Cataract due to a pre-existent pathology, with the appearance of a spontaneous form of opacity, when compared with the slowness of its growth, may be attributed by a malingerer to a traumatic event.

The traumatic cataract is, in general, the consequence of a direct form of injury to the crystalline lens by a physical agent perforating or contusing the cornea and the iris, so that a thorough accurate ocular examination will discover, according to the date of the accident, a recent or old wound of the cornea, a laceration or a detachment of the iris tissue or the presence of a foreign body in the cortical layers of the lens.

Cataracts due to systemic diseases or due to local conditions as chorioretinitis, retinal detachment, glaucoma, intraocular tumors, have general and local typical signs, so that the compliant can not successfully influence the medical observer.

A traumatic cataract is generally unilateral and has quite a rapid evolution while a cataract due to a systemic disease is bilateral and has a slow evolution.

Congenital cataracts not associated with any metabolic or systemic disorder and existing from earliest infancy, may be diagnosed as post traumatic, but are present in both eyes too, while a traumatic cataract is typically unilateral.

Cataracts due to maternal infections as rubella or toxoplasmosis or cytomegalic virus are typically present in both eyes too.

The morphology of congenital cataract and the need for surgical treatment is generally similar in parents and offsprings.

The use of topical or systemic cataractogenic drugs as steroids, miotics (cholinesterase inhibitors), amiodarone, chlorpromazine, busulphan, gold or others must be investigated to differentiate drug-induced cataracts, which are generally bilateral, from traumatic cataracts which are generally unilateral.^{1,3,5}

Sometimes a medico-legal consultant may be asked to explain whether the displacement of the crystalline lens without any apparent rupture of ocular membranes was due to a traumatic genesis or not.

When the displacement was due to the action of a traumatic injuring agent, a careful examination, performed immediately after the accident, discovers the signs of the traumatism and the lens affected by a typical traumatic cataract feature explaining that the traumatism was most probably the exclusive cause of the cataract.

A chronic form of flogosis of the uveal area, with contraction of the vitreous humor both affecting the suspensory ligament of the crystalline and altering the homeostasis between aqueous and vitreous humor, may induce the displacement of the crystalline lens and the development of opacities when a slight traumatic event occurs.

In this case the traumatism was surely the immediate cause of a cataract lesion to which the eye was predisposed after a pre-existent pathological condition.

- (7) The explication whether the patient applied the prescribed form of therapy or neglected to follow it intentionally or not.
- (8) The estimation whether all the expenses for the prescribed medical and surgical treatments were appropriate or not.
- (9) The recognition whether the accident occurred due to illegality or without respecting the law.

It must be taken into account that many traumatic cataracts could have been avoided by using an adequate behavior following correct precautionary and surveillance rules especially when applied in domestic, working, sport and traffic environment.

All the implications reported above underline the importance of a tight interaction between forensic doctors and ophthalmologists to promote a correct medico-legal diagnosis of traumatic cataract.

All clinical data reported on clinical documents or data reported by witnesses or by judicial authorities must be accurately evaluated in order to designate an exhaustive medico-legal examination and to produce adequate conclusions, while an accurate photographic documentation about the clinical grading and morphological features of a traumatic cataract must be regularly applied.^{9,28,36}

On one hand, an ophthalmologist consultant is experienced in stating the cause of an ocular disease, its symptoms, severity, ordinary duration, partial or total permanency but is not qualified, as a medico-legal consultant is, to solve all specific judiciary questions involving the whole causative profile of the accident and its consequences and to apply a correct impairment rating on all temporary and permanent residual dysfunctions.

Finally an experienced medico-legal consultant should be able to identify the evidence of a pre-existent ocular disease in subjects who are making a claim for visual dysfunctions and attributing them to a traumatic event.

In cases of traumatic cataract, occurring in subjects already suffering from pre-existent ocular diseases, it is mandatory to differentiate the level of visual dysfunction due to the injuring agent and that due to the pre-existent pathology.^{9,28,36,37}

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